that are seen when an electric arc light throws the shadow of a flame and its stream of hot air upon a white wall, are therefore quite analogous to those seen during total eclipses. In fact, it might be possible to exactly reproduce the eclipse shadow bands by causing the shadow of the edge of a disk or wall to fall upon a white surface placed at a great distance therefrom, were it not that streams of hot air from the illuminated sides of the wall are apt to overpower the more delicate atmospheric effect that we desire to observe.

When the sun is near the zenith the horizontal movements of the shadow bands must be due merely to the horizontal movement of the atmosphere carrying the warm and cold masses along with it. When the sun is near the horizon then the vertical motion of the shadow bands is principally the result of the vertical motion of the ascending warm or descending cool masses throughout the atmosphere, while the horizontal movement of the shadow bands depends upon the direction of the wind and the bearing of the sun from the observer. In general, the motion of the shadow band on a horizontal surface can be expressed by simple trigonometric formulæ.

The fact that the atmosphere is a mixture of masses of hot and cold air whose movements in the vertical direction are compounded with those of the horizontal wind currents, gives rise to a number of phenomena that interest the meteorologist, among which I may enumerate the following:

1. The scintillation or twinkling of the stars, which is explicable as due to the refractions, dispersions, and occasional interferences of slender pencils of starlight.

2. The jumping and oscillation of the images of the stars and other celestial objects; this constitutes the "bad seeing" or "bad images" of the astronomers.

3. The extinction or absorption of starlight diminishes with increasing altitude of a star above the horizon and depends partly upon gaseous absorption, partly on the obstacles encountered, such as dust and particles of vapor haze and cloud, but also on the diffuse refraction and reflection of the pencils of light as they pass through numerous refracting surfaces in the atmosphere.

4. The extinction of sound as it traverses the atmosphere does not proceed according to the simple law of the inverse square of the distance, but much more rapidly. In fact, owing to the refraction of sound and the influence of the wind, it is quite possible for the sound to pass entirely over an observer and be heard a mile further on where the sound wave descends to the ground. These irregularities were investigated by Prof. Joseph Henry, on behalf of the Lighthouse Board of the United States, and by Prof. John Tyndall, on behalf of the Trinity House of London. Tyndall seems to have shown that in many cases the mixture of hot and cold masses of air renders the atmosphere as opaque to sound as the mixture of water and bubbles of air is opaque to light. The rapid extinction of sound is due to irregular refractions of sound waves in passing through many small regions of varying densities. Often, in fact, we need not many, but merely one or two changes of density. Thus, a cold wind penetrating a mass of warm air acts as a wall, reflecting and refracting the sound wave into directions entirely different from that which it originally had.

5. The numerous photographs of lightning flashes often show great variations in the width and character of different portions of a flash; sometimes the flash appears like a band or ribbon seen edgewise in one portion and frontwise in another. These features may in part be explicable as due to the irregular refractions in the air between the flash and the camera; in fact, if the flash suddenly heats the air in its track so as to produce an explosion, the irregularities of the refraction will be greatly accentuated.

6. We apparently meet with similar irregularities in the study of the sun. Thus, the instantaneous photographs of the whole sun taken by Janssen in 1877 usually show a few regions where the fine regular structure known as "rice grains" suddenly becomes blurred. These spots I have always attributed to the irregularities of the refraction of light in our own atmosphere and not to similar irregularities in the solar atmosphere, although such undoubtedly exist. The latter could only have an infinitesimal effect as seen from the earth and would possibly have a more decided effect near the edge than near the center of the sun's disk. In fact, the apparent rice grain structure may itself be in part due to such irregularities in the solar atmosphere. The suggestion that the blurs on the photographs may be due to optical imperfections in the lenses of the telescope, or any part of the photographic apparatus, was made but soon abandoned by Janssen himself.

Since the above was written the astronomers in the pure air of Arizona have investigated the origin of symmetrical bands of light in the diffraction images of stars in the large telescopes, and have attributed these bands to the refractions at wave surfaces in the upper atmosphere and resulting interferences. The forms and movements of the optical bands are supposed to indicate the conditions existing in the upper atmosphere, but this requires further investigation.

STORM WARNINGS ON THE OREGON COAST.

A remarkably severe storm passed over Astoria, Oreg., on Wednesday, May 23. In connection with this storm the Evening Telegram of Portland, Oreg., says:

> Notice of the coming of the gale was received at an early hour by Weather Bureau Observer Johnson, who wired the several lifeboat crews. They immediately started out and warned the fishermen to seek cover. It is believed that Mr. Johnson's warning reached the fishermen in time to prevent greater loss of life, although many perished in spite of it.

Capt. A. L. Hall, of the steamship *Walla Walla*, arrived at Seattle, Wash., May 25; he estimated the velocity of the wind at fully 90 miles per hour; it was a southeast gale with southwest squalls which made the sea very choppy.

This action of the Weather Bureau displayman in personally visiting and warning the fishermen is, of course, an every day occurrence throughout our coasts whenever storms threaten, but it is worth quoting, as illustrating the fact, that throughout the United States, from one extreme to the other, wherever the atmospheric elements threaten life or property, the officials of the Weather Bureau are also on hand to give prompt warning of the impending danger.

INDEX TO THE MONTHLY REPORTS OF THE CALIFORNIA SECTION.

In the May number of the report from California, Mr. McAdie publishes an index to the articles contained in the Climate and Crop Bulletins from January, 1897 to December, 1899, as compiled by Mr. H. E. Smith. This commendable enterprise on the part of Mr. McAdie has already borne good fruit by calling the attention of the Editor, and doubtless others, to articles that had been overlooked. A general index up to date would form an appropriate page in each of the annual volumes of the section reports.

In this connection it may be worth while for each section director to page his monthly numbers continuously during each year, and print a title page with contents and index for the annual volume.